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Persistence of Benefits from New Building Commissioning

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Project 2.2 - Monitoring and Commissioning of Existing Buildings
Task 2.2.5 - Investigate the persistence of the benefits obtained from different types of commissioning and continuous commissionings

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Synopsis

The commissioning process is gaining increasing recognition as a cost-effective strategy for reducing commercial building energy use. Although the success and cost-effectiveness of commissioning activities depend on how well the benefits of commissioning persist over time, this aspect of commissioning is not well understood.

The persistence of the benefits of commissioning new construction was recently studied as a part of the California Energy Commission Public Interest Energy Research program. Ten buildings that were commissioned as new buildings at least two years ago were evaluated. The commissioning reports, control algorithms, EMCS point measurements, and energy use data were examined to determine the persistence of selected items that were fixed during commissioning. Operator, owner, and commissioning provider interviews were conducted to help determine reasons for persistence and methods of improving persistence.

The majority of the commissioning fixes that were studied persisted. The items that did not persist were typically changes in occupancy scheduling and cooling plant control strategies. Through this investigation, we identified three ways to improve the persistence of benefits of commissioning: operator training and support, improved information transfer from the commissioning process, systems put in place during commissioning to help operators track system performance, and inclusion of design phase commissioning.

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Introduction

Complex building systems are becoming more prevalent in commercial buildings, yet building owners often find that their buildings do not operate at the expected level of performance. Several factors contribute to this lack of building performance. The building industry has become increasingly segmented between the trades, and building industry professionals have been forced to reduce their fees to compete in the prevailing low-bid environment. As a result, quality control mechanisms and building system documentation have been largely eliminated from the building development process, and installation and operational problems have become commonplace.

More and more building owners commission their buildings to verify that the intended design has been implemented and to improve the likelihood that the equipment will maintain this level of performance throughout its life. Building commissioning prevents problems from developing, anticipates and regulates system interactions, and implements a systematic method to meet the building's mechanical, electrical and control requirements. In correcting building problems, commissioning has been found to reduce repair and replacement costs, tenant complaints, indoor air quality problems, and liability and tenant turnover costs.

The fledgling commissioning industry, though growing every year, must resolve several issues to achieve greater penetration in the building industry and receive further support from utility energy efficiency programs. One of these issues is how well the measures that were fixed during commissioning persist over time.

The persistence of the benefits of commissioning was first studied by researchers at Texas A&M Energy Systems Lab. Researchers studied the persistence of existing building commissioning at ten buildings on the Texas A&M campus and found a 17% increase in energy use over a period of two years (Turner et al., 2001). At these buildings, electricity, chilled water, and heating water use is metered hourly, which provided a sound basis for calibrated simulation and evaluation of savings degradation

In August 2001, a California Energy Commission Public Interest Energy Research (PIER) project studied ten buildings that were commissioned as new buildings to address the persistence of benefits of new building commissioning. As the first formal study on persistence of benefits from new building commissioning, the study draws qualitative conclusions about persistence by focusing on three issues: how well the benefits of commissioning persist, the reasons for declining performance, and methods for improving persistence.

Methodology

The PIER research proceeded according to the following steps. A description of each step is listed below.

- Solicit and select buildings
- Select measures to study from the commissioning documentation
- Define criteria for persistence
- Conduct interviews
- Perform site visits for selected buildings
- Perform utility bill analysis
- Determine reasons for persistence and methods for improving persistence

Solicit and select buildings

The project began by soliciting candidate buildings and selecting ten participants. In order to participate, a facility was required to have undergone new building commissioning or commissioning of a major retrofit between 1995 and 2001. A first round of phone calls to California building owners and government representatives whose facilities had previously been commissioned failed to yield ten suitable buildings for the study. Commissioning providers and California utilities were then asked to suggest candidate buildings, based either on their involvement with the project or their record of facilities receiving incentives to perform commissioning.

Commissioned buildings with adequate documentation proved to be difficult to find in California, and as a result the study participants include five buildings in California and five in the Pacific Northwest. It was also necessary to expand the scope of the study to include buildings that did not follow the full commissioning process, defined by ASHRAE Guideline 1 as beginning during programming and design and following through the construction, acceptance, and post-acceptance phases (ASHRAE, 1996). The study evaluated the persistence of the best- documented and most complete commissioning processes that were found. These include pre-functional checks and functional testing. Design-phase commissioning was not typically implemented.

Select Measures

The driving force behind the selection of measures was the amount of information available. Only measures that were implemented as a part of the commissioning process and whose fixes included detailed documentation were included. Many measures were eliminated because the commissioning documentation lacked the information necessary to compare current operation to as-commissioned operation. In addition, a large number of measures were reported as "recommendations" or "pending" and were therefore not eligible.

Qualifying measures fell into three categories: hardware; control systems; and documentation improvements. With limited site visit and interview time, measures were selected to maximize the value of the study results. Control system fixes were chosen because they can have significant impact on energy use and are often easily modified. Maintenance issues such as typical calibration errors and clogged filters were not studied because the persistence of these

items depends more on routine maintenance than the benefits of the original commissioning process. Hardware measures that are fairly static once fixed were not seen as a high priority to study. For example, instances where the commissioning provider found equipment disconnected from the power supply were not included. Finally, changes that resulted from design review are not included because only one building underwent design phase commissioning.

Excluding hardware fixes and design changes that are likely to persist will tend to underestimate the overall persistence of commissioning benefits. The act of choosing measures that were feasible to investigate in the time available adds additional selection bias. For example, it was not possible to evaluate discharge air temperature cycling during cooling operation when the building was not calling for cooling. Due to selection bias, the results of this study are presented in a qualitative manner.

Define Criteria for Persistence

Before evaluating the persistence of new construction commissioning benefits it was important to define persistence. In most cases, persistence or lack of persistence was clear. But measures modified to meet real operating conditions do not persist in exactly the way they were initially fixed during commissioning. For example, the discharge air temperature reset schedule might be slightly modified if comfort requirements could not be met using the setpoints initially implemented. Even if the original reset schedule was more energy efficient, if the modified reset schedule still significantly improved energy efficiency compared to the pre-commissioning operation, then the measure was said to persist. If the reset schedule had been disabled or modified to decrease energy efficiency compared to the pre-commissioning operation, then the measure did not persist. In some cases, the persistence of a measure was subjective, since determining persistence required judging how much the change reduced the effectiveness of the commissioning repair.

Conduct interviews

Telephone interviews were conducted with the person on each facility's staff that was most knowledgeable about the control system. The first interview allowed the researchers to develop an understanding of the building's commissioning documentation and control system. Based on this information, six buildings were selected for site visits and a more detailed investigation of the commissioning measures. A second telephone interview was conducted with the remaining four buildings to discuss the current state of selected measures previously fixed during commissioning. The interviews and site visits provided valuable insight into the reasons for persistence and the methods for improving persistence.

Perform site visits

Budget constraints limited the study to six half-day site visits. Researchers investigated the persistence of selected measures previously fixed during commissioning, and also gained an understanding of the resources available to the operations staff by examining commissioning documentation, system drawings, O&M manuals, and operator training opportunities. The site visit provided the opportunity to evaluate the current state of system operation and documentation, and also to assess the environment within which the facility's staff operates, including support for training and the time available for troubleshooting.

Perform utility bill analysis

The bottom-up analysis of the persistence of commissioning fixes was supplemented with utility bill analysis to document the energy consumption of the building over time. Due to lack of utility bill data in some cases, only half of the buildings were analyzed. Energy use comparisons were initially performed using direct utility bill comparison for each year after commissioning; this was followed by weather-normalized comparison using baseline models and the Emodel program (Kissock et al. 1994). A common weather year was selected to normalize the consumption data for weather variation using the procedure described in Turner et al. (2001). This weather normalization procedure assures that the variations in consumption determined are not the result of year-to-year weather variations. After a normal weather year was selected, the annual energy consumption for each year was modeled and recalculated using the weather parameters from the normal year. The normalized annual consumption values were then compared to determine the presence or absence of consumption changes.

Results

The results of this study can be broken into two categories: findings due to the difficulties in performing the study and findings related to the persistence of commissioning fixes. This section presents reasons why buildings were difficult to locate and reports the persistence of the measures studied. It is important that the discussion of the level of persistence of specific measures selected for the study be considered in relation to the value of the original commissioning process at each facility. The measures selected for study are only a small subset of the total items fixed during the commissioning process. From 20 to over 100 commissioning items were documented at each site. Most of the building operators and managers felt that an extensive commissioning effort was essential.

Identifying Appropriate Sites to Study

Identifying buildings in California that qualified for the study was a long and difficult process. The effort to contact California building owners, commissioning providers, and utility representatives began in August 2001. By March 2002, forty-seven building contacts had resulted in only five qualifying participants. By comparison, in Oregon only twelve contacts were required to yield five suitable buildings. It may have been easier to find commissioned buildings in Oregon because there is a longer history of new building commissioning in the Pacific Northwest, relative to other parts of the U.S. The study identified several reasons why California buildings with the required documentation were difficult to locate:

1. **Commissioning summary reports were often not written.** The extra effort required to summarize the commissioning findings in a formal report was often not completed. Therefore, there were instances when the volumes of information produced through commissioning were not put in a summary or a systems manual that could be used by facilities staff to better understand their systems. One common format for the commissioning documentation was a series of memos (or "punchlists") that listed items for the contractors to fix. As these problems were fixed and removed from the list, the details of the changes often were not documented.

2. **If commissioning summary reports were written, they were often not available to the owner or operators.** Commissioning documentation was typically filed away in storage, unavailable, and not organized for easy reference. Commissioning providers, utility representatives, and building staff that had access to these large volumes of documentation did not have sufficient incentive to spend the time sorting through this documentation. Ten buildings that had gone through the commissioning process did not have any commissioning documentation available.

3. **New construction commissioning activities did not seem to be widespread.** Buildings that were commissioned as new construction in California between 1995 and 2001 were difficult to find, although the study identified many existing building commissioning projects (often referred to as "retro-commissioning"). Six new building commissioning projects that were too new for the study were also found.

4. **Many potential measures listed in the commissioning reports could not be investigated because they were only recommendations and may not have been implemented during commissioning.** Commissioning ideally results in a fully operational building, but often in reality, a number of problems remain after commissioning is formally completed. Within the list of commissioning findings, some of the findings had not been resolved. These measures were labeled as "recommendations" or "pending". Problems left unresolved in the formal commissioning process are often expected to be implemented by operations staff during the first year(s). Since it was difficult to determine when or if these recommendations were followed, they could not be classified as benefits of the commissioning process. Three sites could not be selected because the majority of commissioning findings were only indicated as recommendations.

The lack of commissioning summary documentation and unresolved building problems point to the use of "commissioning" as an umbrella term for a variety of activities. This finding is supported by previous market research in California. The research identified that education is needed on the commissioning process, since the majority of owners define commissioning as primarily the testing of systems (Haasl and Friedmann, 2001). In this study, each commissioning process encountered was defined differently. Troubleshooting activities during construction and simple checklists were referred to as commissioning. In the search for buildings participants, commissioning providers and owners often said of their project, "This was not a good example of commissioning," because the process was inserted late into the construction process or had a contentious end. In effect, the persistence of the entire commissioning process, from design-phase to post-occupancy, was not investigated. Instead, the focus was the variety of ways in which commissioning is implemented in practice.

Persistence of Specific Measures

Analysis of the persistence of specific measures is the heart of this study, from which the qualitative conclusions about persistence are drawn. The availability and use of the commissioning report and written sequences of operation were examined at all sites, as possible

factors for ensuring persistence. Figure A shows the measures that persisted (light gray squares) and did not persist (black squares) at each of the ten sites. A square split in half horizontally indicates that more than one measure was investigated in the category.

	BUILDING (year commissioned)	DOCUMENTS			CENTRAL PLANT				AIR HANDLING AND DISTRIBUTION								PREFUNCTIONAL TESTS					OTHER		
		Commissioning report on site	Commissioning report used	Control sequences available	Chiller control	Cooling tower control	Boiler control	Hydronic control	Economizer control algorithm	Discharge air temperature reset	Simultaneous heating and cooling	VFD modulation	Dessicant cooling	Duct static pressure	Space temperature control	Terminal units	Piping and fitting problems	Valve modification	Wiring and instrumentation	Sensor placement or addition	Sensor error or failure	Scheduling	Skylight louver operation	Occupancy sensor
California	Lab and Office 1 (1996)	no	-	yes																				
	Office Building 1 (1996)	no	-	yes																				
	Office Building 2 (1996)	no	-	no																				
	Office Building 3 (1996)	yes	yes	no																				
	Office Buidling 4 (1994)	no	-																					
Pacific Northwest	Office Building 5 (1997)	no	-	yes																				
	Medical Facility 1 (1998)	yes	yes	yes																				
	Medical Facility 2 (1997)	yes	yes	yes																				
	Lab and Office 2 (1997)	no	-	yes																				
	Lab and Office 3 (2000)	no	-	no																				

Figure A: Persistence of equipment and controls fixed during commissioning. Light gray boxes show measures that persisted and black boxes show measures that did not persist.

Across the ten buildings studied, patterns for the types of commissioning fixes that persisted emerged. Fifty-five commissioning fixes were studied, and the large majority of the measures persisted. Items such as repiping and correcting wiring, once addressed, become relatively passive elements in the system, and therefore persisted. Other hardware fixes, such as adding a control valve, also tended to persist. When control system programming code was modified, these changes often persisted, especially when occupant comfort was not compromised. Most of the hydronic control problems were fixed with control programming changes. Many design-phase fixes may also persist, but we were not able to study this issue since only one building had design-phase commissioning.

Control strategies that could easily be changed without modifying the programming code had the most problems with persistence. Four out of six occupancy schedules did not persist. Chilled water system control strategies did not persist in three out of eight cases. Study of sensor issues was limited to major sensor problems that were corrected during commissioning, such as sensor failure or excessively faulty readings. With these selection criteria applied, two out of four sensor repairs did not persist.

Some new or "exotic" technologies did not have documented commissioning repairs, and thus were not formally selected for study, but it became apparent that these measures tended to have

problems. For example, evaporative cooling was disabled, demand control ventilation was not maintained, dimmable ballasts failed prematurely, desiccant cooling failed, and a natural ventilation cycle was problematic. While some of these persistence problems may have originated from a mechanical problem, the lack of operator training in these technologies contributed to the lack of persistence. Operators were often not trained in the proper control sequences and maintenance procedures for these systems.

Almost every operator interviewed stressed that design problems continue to require their attention. Nine of the buildings did not include standard design phase commissioning. Regardless of whether or not the design problems were fixed during commissioning, these problems are significant to persistence because operators that constantly battle design problems had less time to troubleshoot the performance of the rest of the building. The operators were aware of the lack of design phase commissioning and expressed that these problems should have been caught during a design review process.

Utility Bill Analysis

The consumption of electricity and gas is shown in Figures B and C, respectively, for the years after each building was commissioned as a new building. Then the weather normalized consumption change is shown for successive years as a percent increase (+) or decrease (-) compared to the baseline year. The baseline year is defined as one full year of post-commissioning data.

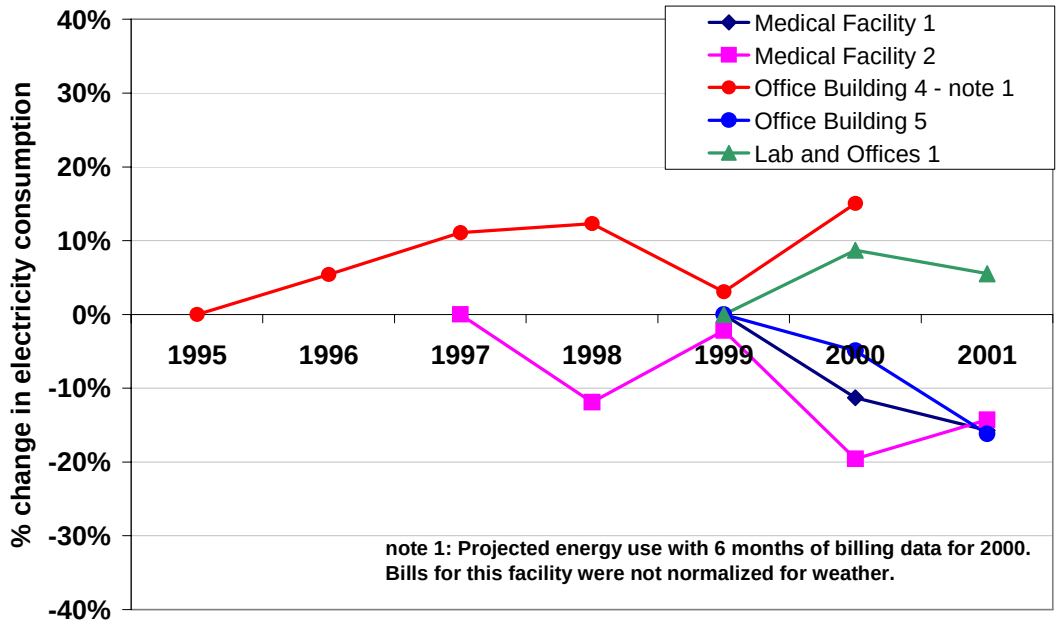

Figure B: Change in Electricity Consumption in Commissioned Buildings Over Time

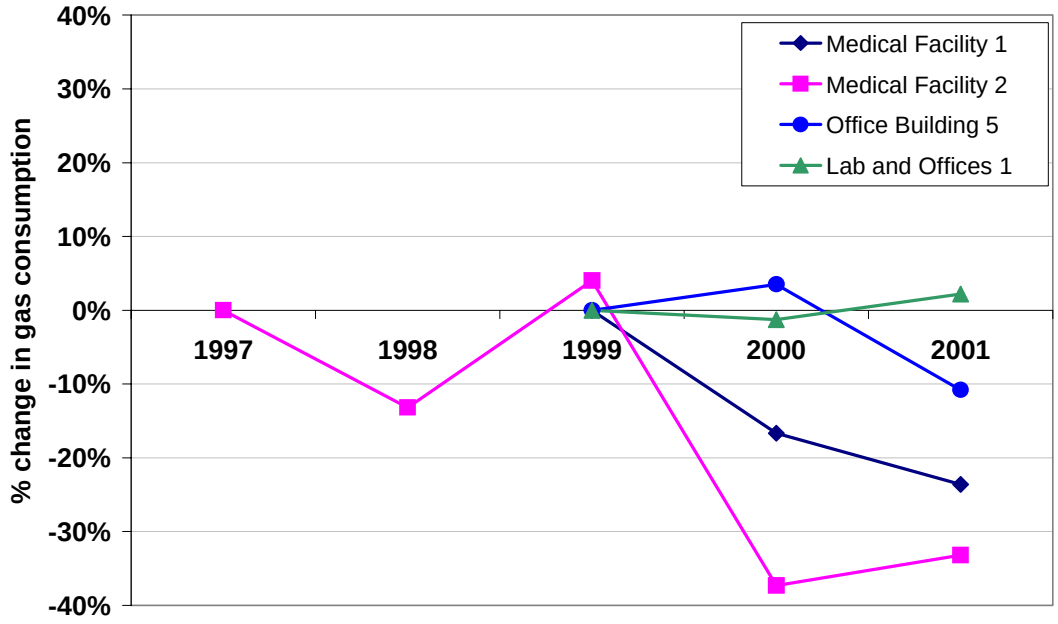

Figure C: Change in Gas Consumption in Commissioned Buildings Over Time

Three of the five buildings showed lower consumption in years two and three following commissioning. On average, electricity use declined by 3% and gas use by 7% in the second year following commissioning. Electricity use was down by 3.5% and gas use by 7% in the third year (relative to the first year).

Discussion

This study showed that the majority of commissioning measures persisted. However, many measures at each building were not studied and the energy impact of the measures that did not persist was not determined. Analysis of available utility bills showed decreased energy consumption over time for three of the buildings. These buildings may have continuously improved their systems to achieve these savings. The energy crisis in California and other Western states in 2000-2001 also played a major role in conservation strategies implemented during that time. For instance, Office Building #5 implemented greatly reduced lighting levels in hallways.

One cannot necessarily conclude that the benefits of commissioning persisted or that operators improved the efficiency of the HVAC systems over time. Rather, reduced consumption may have been in response to the high energy rates seen during the energy crisis. Without a log of energy saving activities and submetering of lighting, plug loads, and HVAC, it was not possible to discern from the data the change in energy consumption that relates to building performance.

The issues identified in this study are critical issues in our ability to study persistence, and should be addressed in future work.

The findings on the persistence of the measures studied, coupled with an understanding of the operating environment at each building, point to probable reasons for declining or persisting performance and methods for improving persistence.

Reasons for Lack of Persistence

Problems with the persistence of new building commissioning benefits were found to be mainly due to control system changes made by the operator, lack of maintenance, and lack of sensor calibration. This investigation identified three main reasons for these problems: limited operator support and operator turnover; poor information transfer from the commissioning process; and a lack of performance tracking.

First, many of the operators interviewed did not have adequate support for maintaining their buildings. This support includes training on the intended system operation and control sequences, the time to proactively assess building operation, and guidance and motivation for assessing energy use. Without adequate time and training, preventative maintenance problems are likely to be overlooked, leading to issues such as poorly calibrated sensors and disabled subsystems. Operator turnover was a major factor in the lack of knowledge about the intended system operation. Operators became more knowledgeable about the operation of their systems when they were involved in the commissioning process. When these operators left the facility, the knowledge was often lost. In general, a new operator's training consisted of about a one-day walk-through with the former operator. In some cases, operator training at the end of the commissioning process was inadequate. At one building, forms for retesting a lighting system were provided with the commissioning report, but the operators were not trained on system operation.

In addition to operator training, transferring information from the commissioning process to building operation can occur through documentation. This information, in the form of a systems manual or a commissioning report, aids persistence by giving operators the necessary systems information to maintain equipment and troubleshoot problems. In almost every case, it was difficult to locate the commissioning report. For the buildings selected, seven out of ten commissioning reports were not available on-site. The lack of documentation on how the systems should run may lead to uninformed control system changes.

Building engineers reported that commissioning focused on the short-term goal of providing a well-functioning building before the contractors leave. The commissioning documentation was a secondary benefit, but one that has implications for the future operation of the building. If commissioning documentation is not available, there may not be a reference point for how the building should run. For a new owner or operator, this lack of information limits the understanding of the intended operation, and ultimately could result in problems with troubleshooting and decreased performance. If the systems knowledge gained from the commissioning process is not available to the current operators through documentation or training, the value of commissioning is lessened in the long run.

Tracking energy use or key performance parameters were not generally established through commissioning or implemented after the final report was provided. Point histories and other

control system data were occasionally viewed to troubleshoot a known problem, and not as a way to detect problems. It was clear that the operators were too busy responding to comfort complaints, performing routine maintenance, and troubleshooting problems to assess system efficiency. The baseline (as-commissioned) energy use was determined at only one building. The result is that operators would need to establish this baseline for comparison to the current performance.

Performance tracking begins with the utility bills. Operational problems such as off-hour operation and high base load energy consumption can be analyzed from utility bill data, but this practice occurred at only one building. In four out of the ten buildings, the building operations staff had been alerted by administration of suspicious changes in energy use, but the operators did not view the utility data directly. In five buildings, the operations staff did not have access to information about energy use.

Reasons for Persistence

In the limited number of buildings studied, persistence of commissioning benefits seemed to be dependent on the working environment for building engineers and maintenance staff. A working environment that was supportive of persistence included adequate operator training, dedicated operations staff with the time to study and optimize building operation, and an administrative focus on building performance and energy costs. Trained operators were knowledgeable about how the systems should operate and, with adequate time and motivation, they evaluated and improved building performance. In five buildings, operators participated in the commissioning process, and the majority of these operators said that they came away with a good understanding of their systems. In addition, good system documentation in the form of a system manual served as a troubleshooting resource for operators at two buildings. Administrative staff can help enable a supportive working environment by placing a high priority on energy efficient systems and operator training. Only a few of the buildings studied seemed to operate in this supportive environment, and the measures investigated at these facilities had a high level of persistence.

Other measures persisted because there was no reason for change, and the measure could persist without maintenance. For example, if a controls repair during commissioning did not affect comfort in the subsequent years, then the controls most likely were not modified. Additionally, if a controls fix was buried in the programming code, most operators could not change it without hiring the controls contractor. Hardware repairs, often found during pre-functional tests, also tended to persist because there was no reason to intervene.

Four Methods for Improving Persistence

The final goal for this study was to identify ways in which persistence may be improved. These methods were developed with the people who have the most control over the persistence of commissioning benefits in mind - building engineers and operators.

1. Provide operators with training and support

High operator turnover makes training and documentation critical to help ensure that the benefits of commissioning persist over time. A supportive environment for the building staff facilitates energy tracking and proactive troubleshooting. Building operator certification is one means of providing this advanced training (Price, 2001).

2. Provide a complete systems manual at the end of the commissioning process.

The systems manual is the institutional memory for the building, and this information assists the staff in ensuring that the benefits of commissioning persist. The systems manual should include the design intent, system descriptions, sequences of operation, and a commissioning report. The commissioning report should summarize the deficiencies found during commissioning and set the baseline performance of the building. If the systems knowledge gained from the commissioning process is not available to the current operators, the value of commissioning is decreased in the long term. Without adequate system documentation, the baseline operation of the systems after commissioning is unknown. It is this baseline to which current operation should be compared over time through a tracking method.

3. Track building performance

New building commissioning efforts should help implement mechanisms for performance tracking, including what information to track, how often to check it, and the magnitude of deviations to address. Using the baseline operation documented in the systems manual, operators can monitor whole building energy use and the efficiency of major equipment. The performance tracking system could also provide assistance in troubleshooting when deviations from the baseline are detected. These performance tracking activities are beginning to be automated by a number of diagnostic software tools (Friedman and Piette, 2001). Training for these tracking efforts is essential for success.

4. Start commissioning in the design phase to prevent nagging design problems.

The most cost effective benefits of commissioning often occur during the design phase, when changes in design are made on paper, rather than during construction or after construction is complete. These changes would likely have high rates of persistence.

A manual describing these strategies for improving the persistence of commissioning benefits will be available in July 2003. The manual focuses on providing building managers the arguments behind why each strategy is important, and an overview of tools for implementing these strategies. Commissioning providers will also find this manual useful as they strive to improve the persistence of their services.

Future Study

Studying the persistence of commissioning benefits retroactively is very difficult, mainly due to missing building and commissioning documentation. Without a good understanding of the improvements that the commissioning process made, determining if these improvements have persisted is futile. Building documentation such as commissioning reports or systems manuals need to include this detail about the measures fixed during the commissioning process. When studying whole building energy to determine persistence, one must have detailed information to separate changes in energy due to building use changes and changes in energy due to system performance. This documentation includes records of changes in building occupancy, use, and conservation strategies (as a response to energy crisis). Without this information, it will be difficult to tease out of the energy bills the increase or decrease in usage over time due to problems with persistence.

As a result of these documentation issues, it is difficult to quantify how well the benefits of commissioning persist. Future research needs to begin with better commissioning documentation. And due to the complexity of measuring persistence, this research needs to be carefully planned for implementation retroactively, as well as with future commissioned buildings.

To address this need, an integrated plan for studying the persistence of commissioning benefits should be developed. This plan will outline the data that needs to be collected during commissioning in order to study commissioning benefits. Future work should build upon the 10 building study by analyzing more buildings with better data from both a macro (whole building energy use over time) and micro (persistence of specific measures) viewpoint. The macro view will be better represented in a future study through the use of submetering and building event logs. The micro view will be better represented in future study through better documentation of the findings and resolutions during the commissioning process.

The Commissioning Case Study Database is a recent project funded by the California Commissioning Collaborative and Pacific Gas & Electric Company as a way to standardize case study information across California commissioning projects. In this manner, commissioning cost and benefits information can be gathered and analyzed in a standardized way. The Commissioning Case Study Database also provides a key opportunity to collect the information necessary to study the persistence of these benefits.

The results of future studies will be valuable to the utility program managers interested in assessing the value of commissioning as well as commissioning stakeholders interested in ensuring the persistence of the benefits of commissioning. As more buildings are studied, we will better understand the expected “life” and resulting cost-effectiveness of the commissioning process.

Conclusions

While many of the commissioning benefits studied did persist, there are a number of strategies that can be used to improve persistence. The lack of commissioning documentation and a limited level of support for operators in the commissioned buildings we studied did not promote persistence. Even with these shortcomings, a large number of the measures fixed during the commissioning process persisted. Operators and owners consider the commissioning process as essential for providing well-functioning HVAC and lighting systems - views that are supported by the large number of problems identified and resolved at each building.

Further research is needed in this area. To quantitatively document the level of persistence in newly commissioned buildings a much larger sample must be studied, building documentation made more complete, and more time allocated to investigating the persistence of specific measures.

The success and cost-effectiveness of commissioning depends on how long the benefits persist. Without a good understanding of how to improve persistence, many benefits of commissioning will be lost. Bridging the gap between building commissioning and day-to-day operations is a challenge that should continue to be addressed by the commissioning industry.

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